# EVALUATION OF TRANSPORT OF PARTICULATE MATTER AND ITS PRECURSORS INTO AND OUT OF THE SAN JOAQUIN VALLEY, CALIFORNIA: FIRST STEP, MIXING DEPTH

Clinton MacDonald
Mark Lilly
Paul Roberts
Willard Richards
Sonoma Technology, Inc.
Petaluma, CA

Presented at the American Association for Aerosol Research (AAAR) 2003 Annual Conference
Platform Session 7: California Regional Particulate Air Quality Study, paper 7B3
Anaheim, CA
October 22, 2003

# Topics

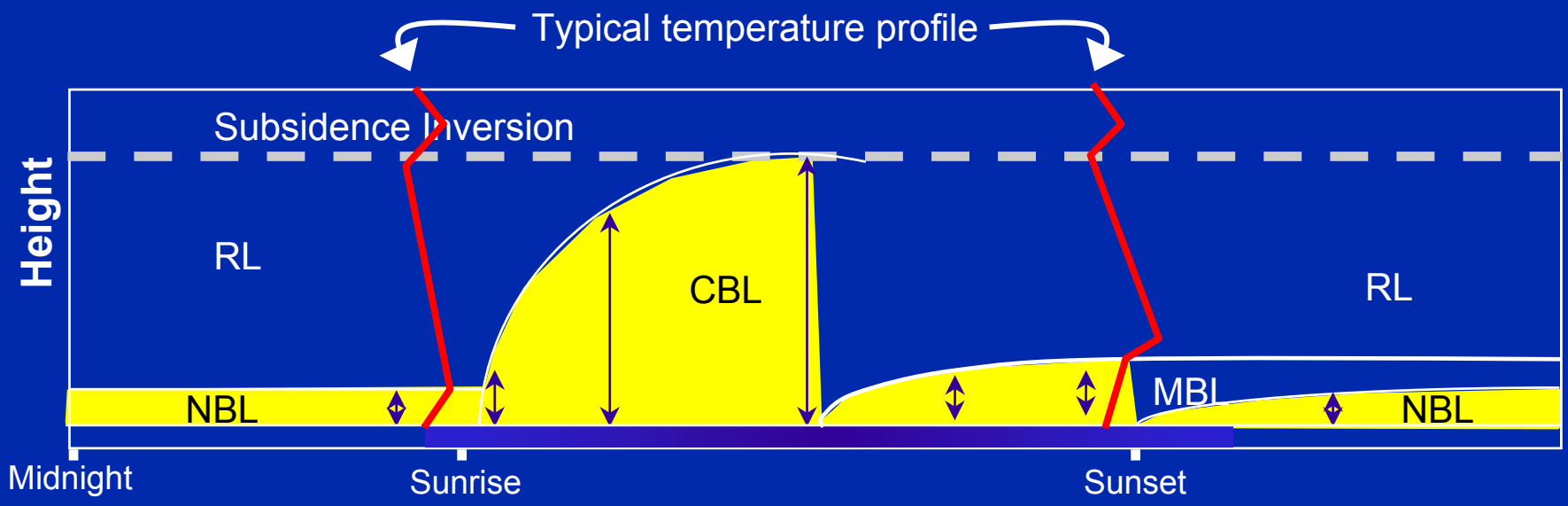
- Flow pathways and inter- and intra-basin transport
- Eddies and the nocturnal jet
- Flux planes and flux of particulate matter (PM) and PM precursors
- Transport and synoptic meteorology
- Advection and diffusion

# Main Tasks

- Creation of Wind Fields
- Transport Analysis
- Descriptive Analysis

– Radar Wind Profiler (RWP) and Radio Acoustic Sounding System (RASS) data quality assurance (QA)
– Estimation of mixing depths
– CALMET modeling
– Trajectory and dispersion runs
– Case study analyses using meteorology and air quality data

# Mixing Depth




= **Surface-based mixing depth**

= **Surface-based vertical mixing**

RL = Residual Layer
CBL = Convective Boundary Layer
NBL = Nocturnal Boundary Layer
MBL = Marine Boundary Layer

# Mixing Depth – Data and Methods

- Mixing depth is the maximum height to which pollutants emitted near the surface will be mixed.
- Mixing depths can be determined using a variety of RWP, RASS, and Sodar data:
  - RWP
    - Reflectivity ($C_n^2$,SNR)
    - Vertical velocity (*w*)
    - Spectral width
    - Horizontal winds
  - RASS
    - $T_v$ profiles to about 1500 m above ground level (agl)
  - Sodar
    - Reflectivity
    - Winds

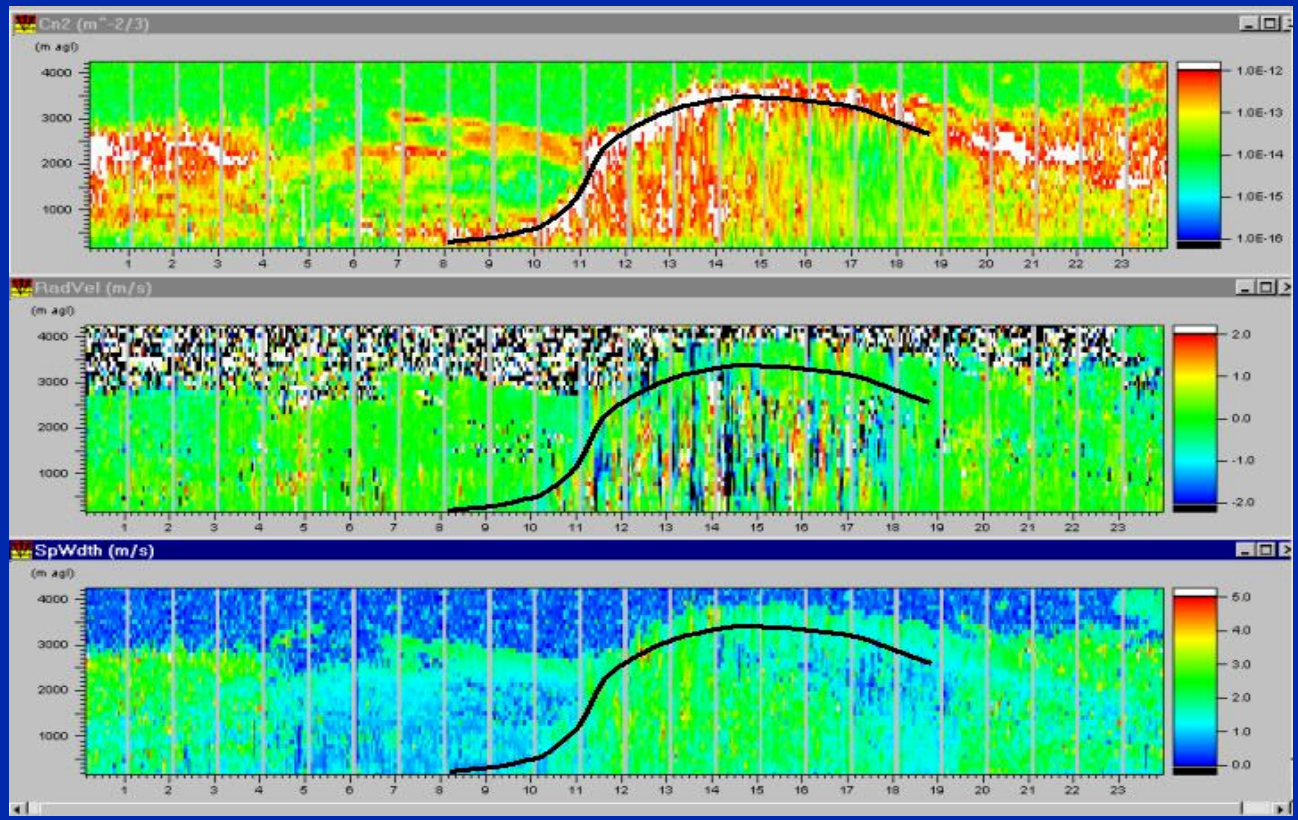
# Mixing Depth – RWP

Estimating Mixing Depths

$C_n^2$

Vertical Velocity

Spectral Width



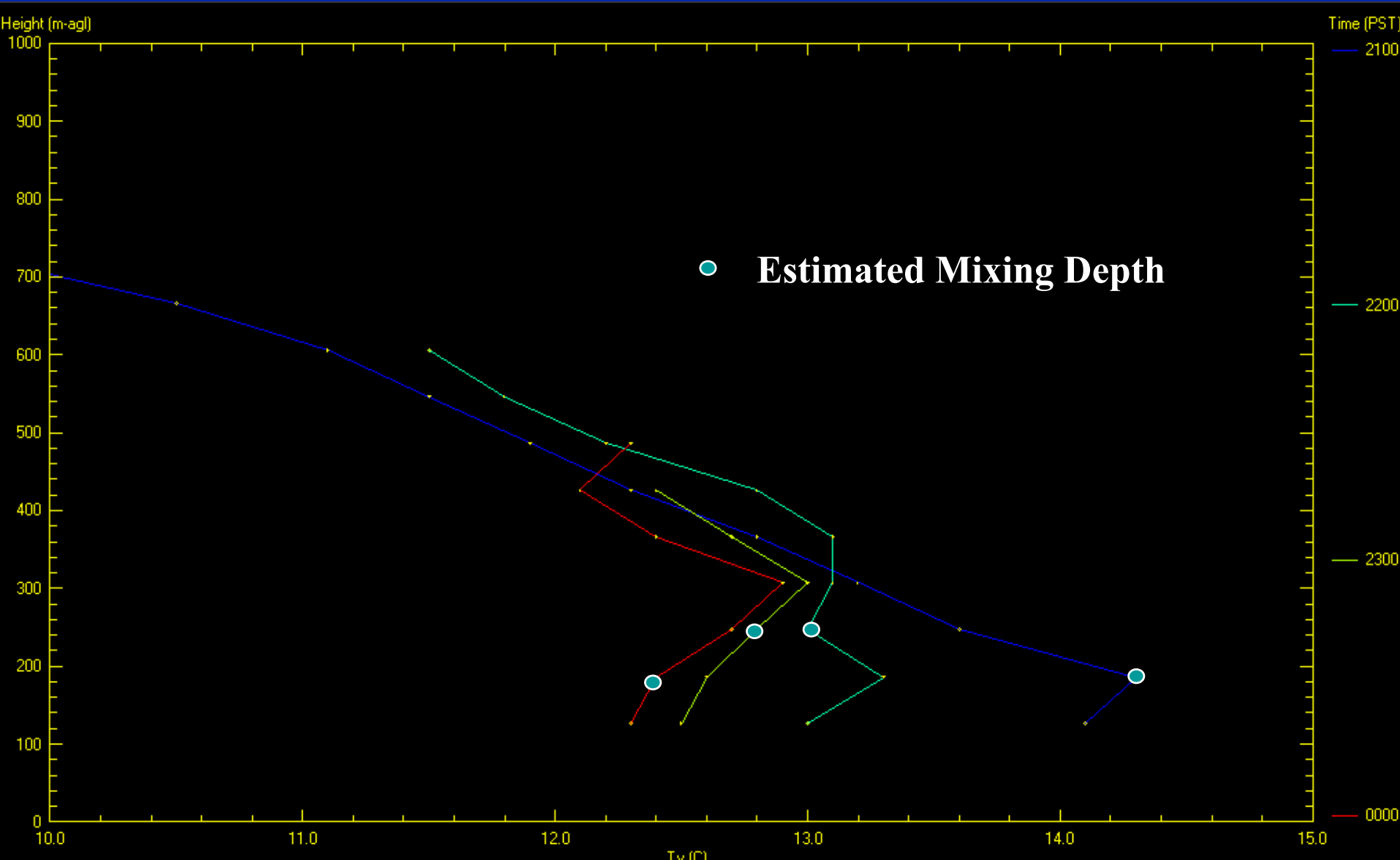

**Issue: Doesn't work well at night or under stable conditions**

# Mixing Depth – RASS

Methods using $T_v$ profiles

- Inflection point
  - Identifies the capping inversion
  - Issue: Can overestimate mixing depth under stable conditions
- Gradient Richardson number (Ri)
  - Ratio of buoyant forces to shear forces
  - Critical value identifies when shear force overcomes stability
  - Issues: Very sensitive to small errors in wind or temperature data; time and height averaging
- Time continuity analysis (new method)
  - Analyze hourly changes in vertical temperature to determine mixing

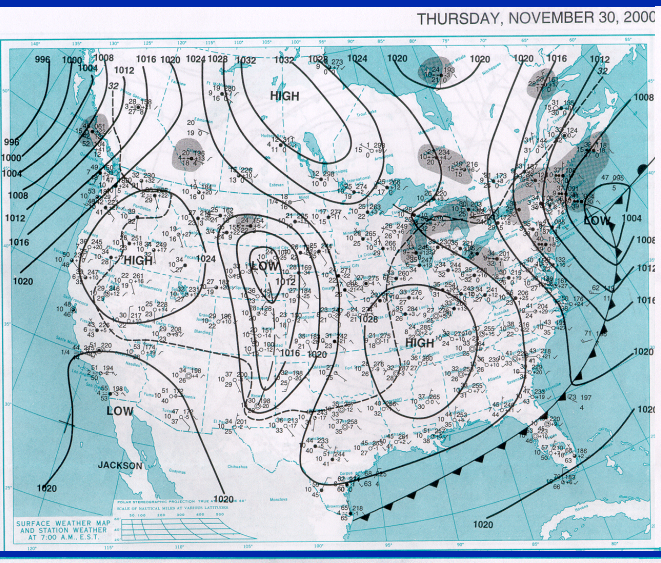
# Mixing Depth – Time Continuity Analysis

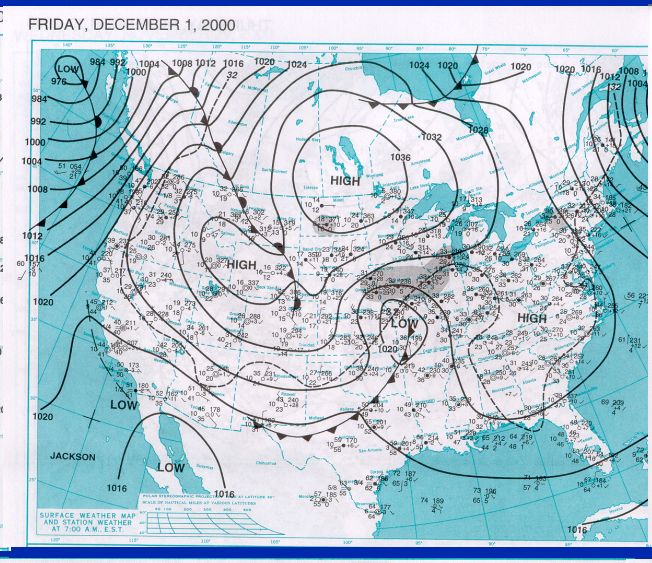


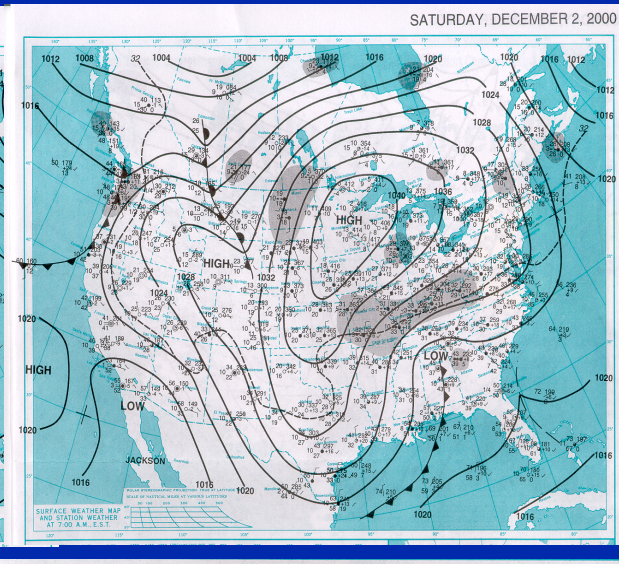
# Profiler/RASS Sites

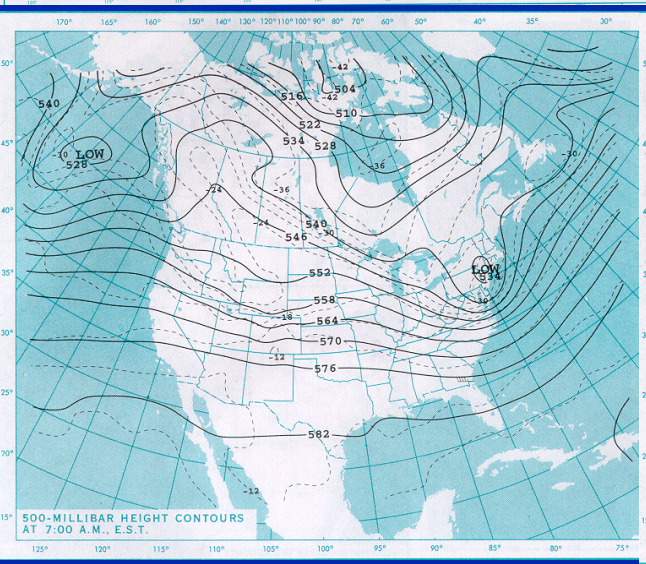

Hourly mixing depth being created for about 20 sites (depending on data availability) for 12/18/2000 through 1/24/2001 and selected episode days

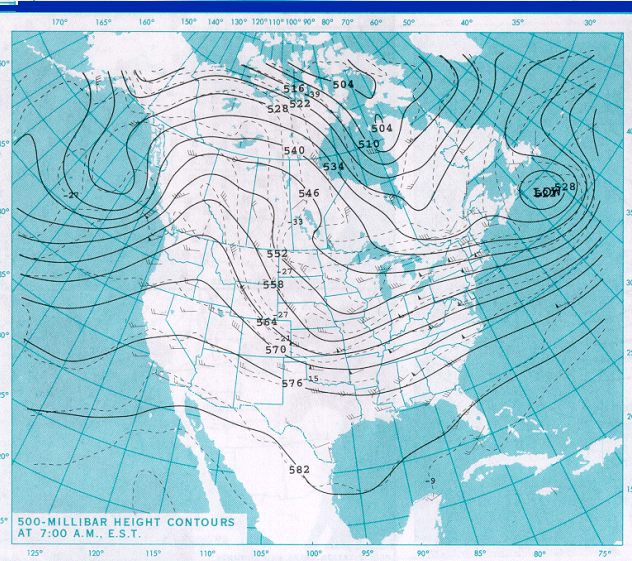
# Case Study Example
# 11/30/2000 through 12/2/2000

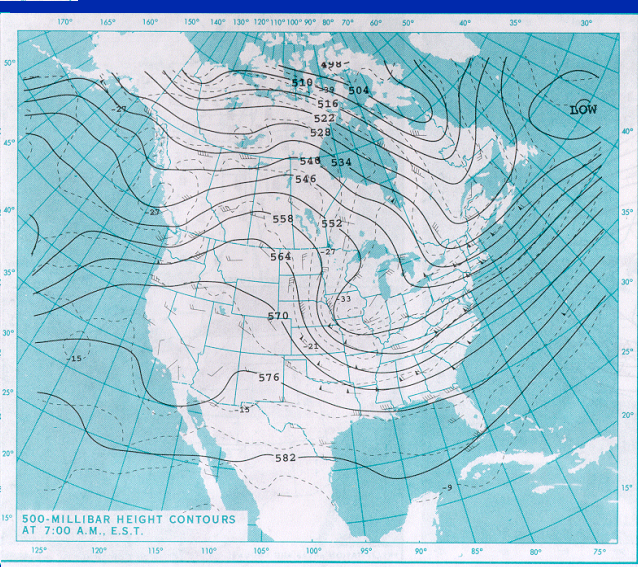


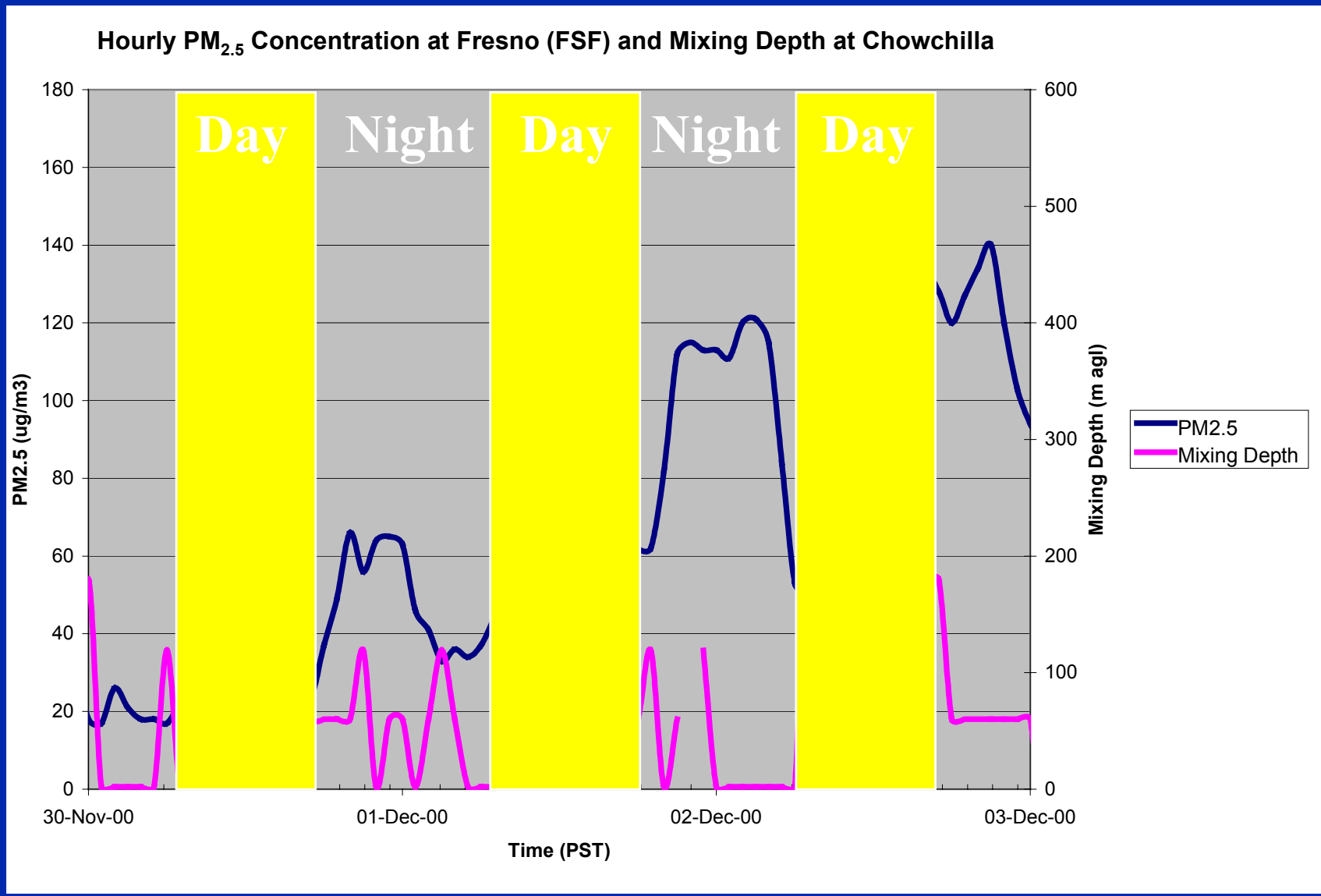



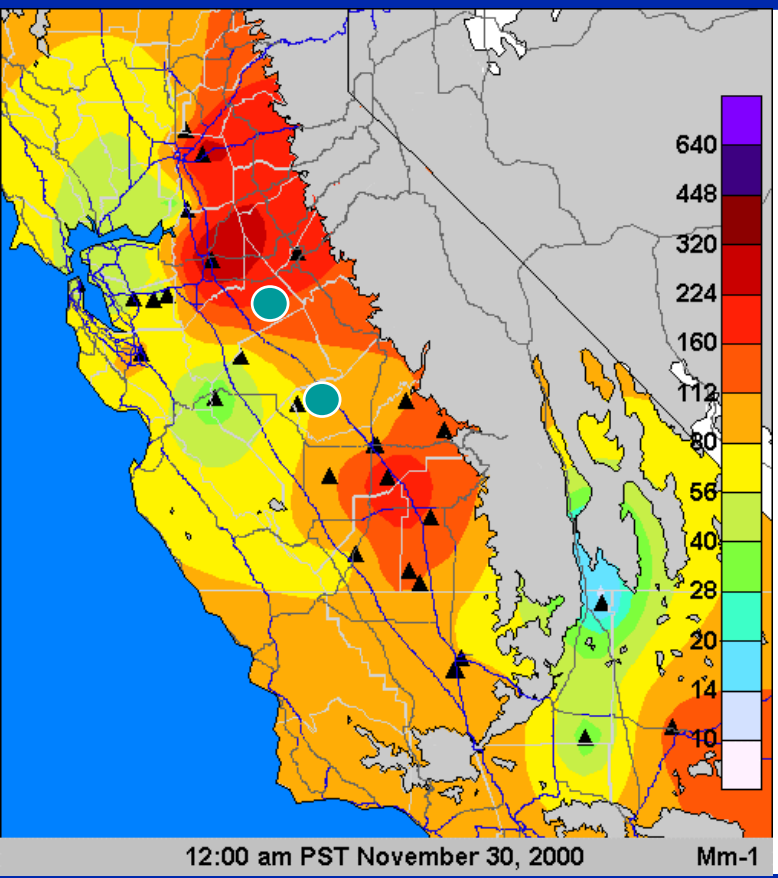



# Case Study Example – Mixing Depth vs. $PM_{2.5}$

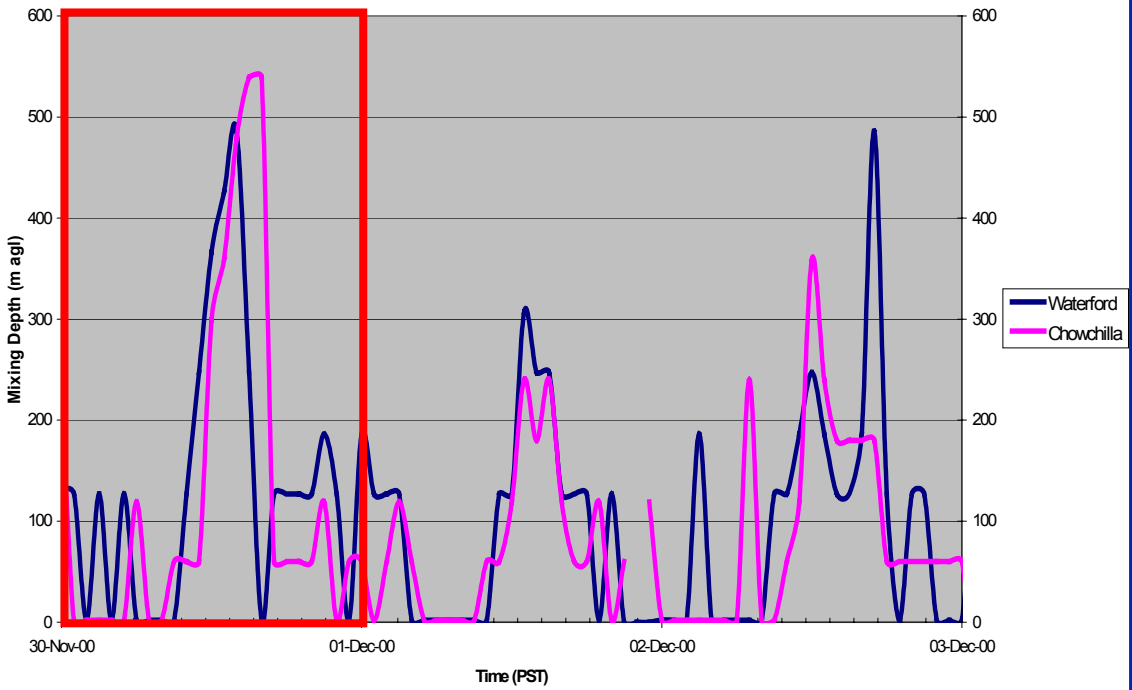


# Light extinction ($b_{sp}$) November 30, 2000

$b_{sp}$

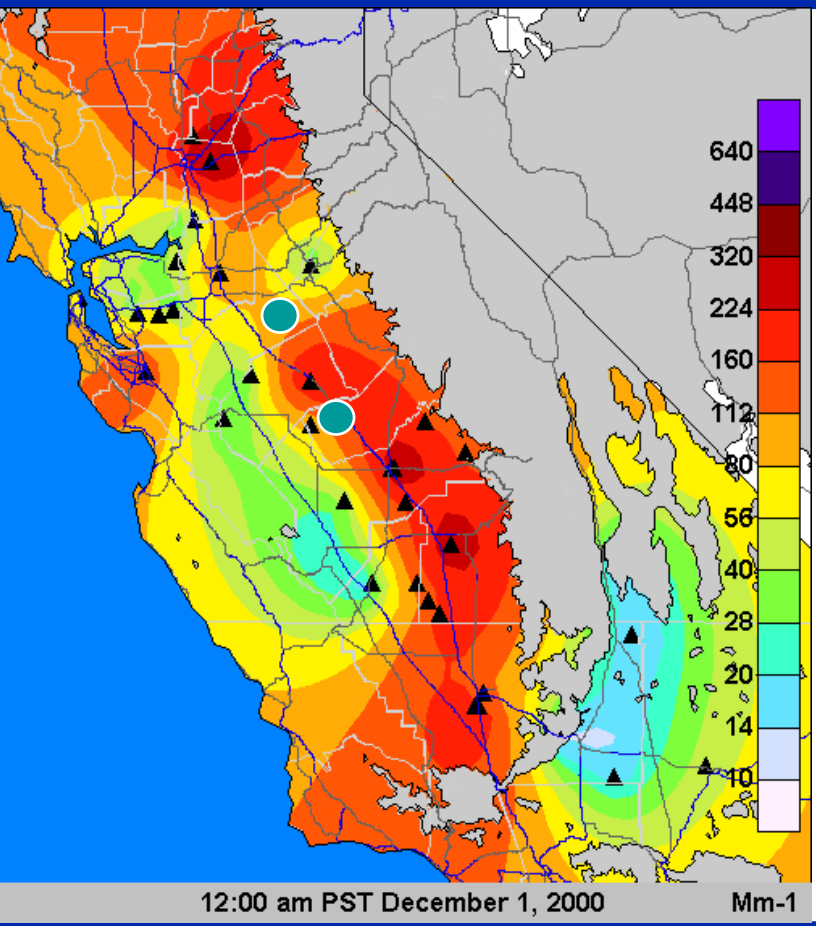



Mixing Depth

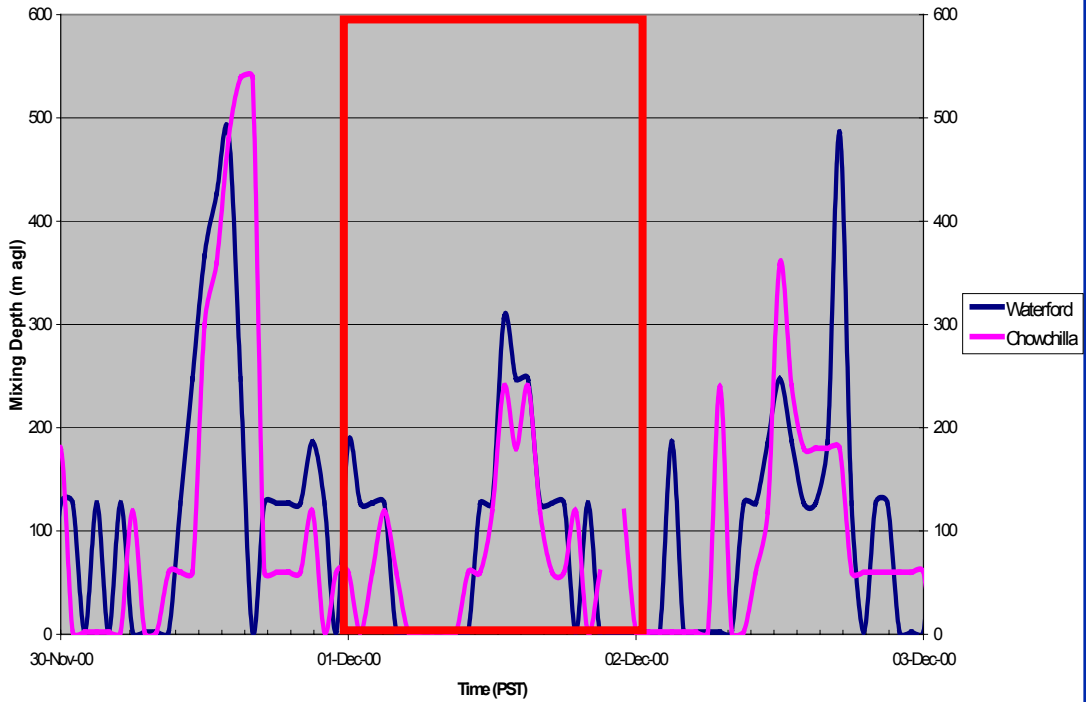


# Light extinction ($b_{sp}$) December 1, 2000

$b_{sp}$

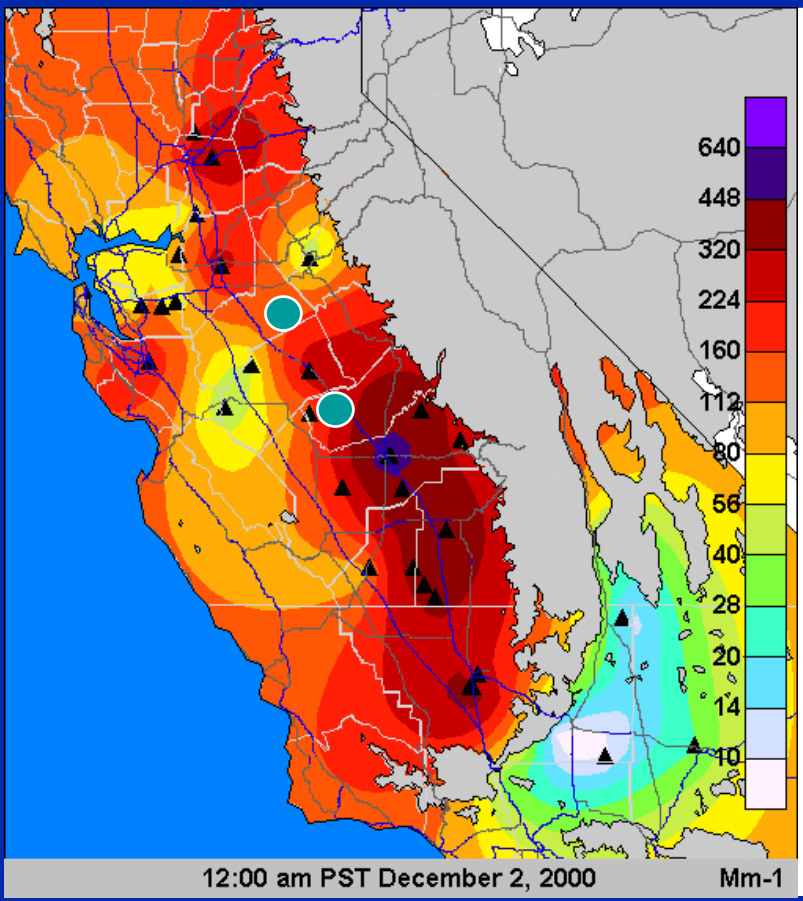



Mixing Depth

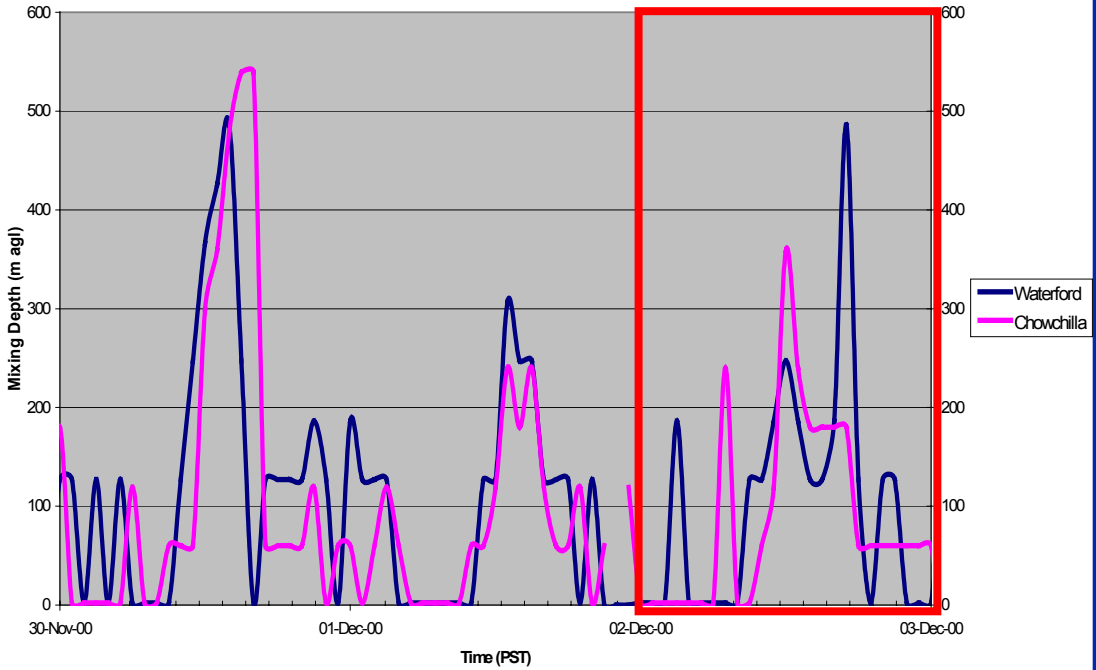


# Light extinction ($b_{sp}$) December 2, 2000

$b_{sp}$




Mixing Depth



# Summary

- Evaluation of vertical mixing is an important aspect of understanding transport and dispersion of pollutants.
- Time continuity technique using RASS data to estimate mixing depths under stable conditions is an effective automatic method.
- Mixing depth data will be made available to other scientists to use in their analyses.

# Next Steps

- Quality-assure mixing depths
- Perform CALMET model runs for selected episodes
- Perform transport and dispersion analysis using model output, observed winds and mixing, and air quality data